

Overall Revised Vital Signs

Below are the revised network Vital Signs. This list has been developed by incorporating the “Revised Vital Signs” from each of the individual sessions presented previously in this document. As necessary changes have been made to rectify differing suggested revisions. Note, the VS Id# field has been redone.

Eco Char	Vital Sign Category	Monitoring Objectives	VS Id#	Vital Sign	Monitoring Question(s)	Monitoring Method	Measures and Metrics
Human activities & cultural practices	Soundscapes	Monitor sound sources, frequencies, occurrence, and levels	H1	Alien, Natural, Human Soundscapes	Are alien sounds appropriate to management zone? Are naturally present sounds maintained at appropriate frequencies, occurrence, db levels? Are we exceeding an acceptable level of sound?	point/plot sampling	frequency (hz), frequency (time), Sound durations, Sound levels, sound source identification, spatial distribution
	Viewscapes / Lightscapes	Monitor landscape / seascape appearance	H2	Viewsheds	Are landscapes/seascapes changing in and surrounding the park? If so, how?	historical photos (periodic photography from fixed points)	qualitative, % of change, presence/absence
		Monitor light levels and characteristics of light/dark cycles	H3	Lightscape & Night sky	Are natural light/dark cycles maintained as appropriate (eg no inappropriate shading, etc)? Is artificial light appropriately shielded? Is artificial light restricted to basic human safety needs only? What is impact on night sky from artificial light sources outside the park?	above ground (aerial or satellite) vs on ground measurements (photographs) count of artificial light sources within park, calibrated/repeatable.	Light intensity, spatial distribution, temporal frequency, color. Baseline not greater than 10% deviation.
	Land Use	Monitor points and pathways of entry to the park for invasive species	H4	Alien Invasive Species Points/Pathways of Entry	How are invasive species getting to the country/state/island/park? What potential high-impact species have breached the border-protection system and have potential to reach the park?	Identify existing and new points & pathways of entry. Monitor for incipient species along known points/ pathways of entry. Identify targeted "blacklist" species of concern that warrant eradication/containment.	Presence-absence, identification & distribution of targeted "blacklist" species & other novel (previously undetected) invasives.
		Monitor land use within, adjacent to, or upstream of, park boundaries	H5	Land Use(s) Within & Surrounding Parks	What areas are most at risk due to conflicting adjacent changes in land use (e.g. ranching, urbanization)? What land use changes are occurring within and adjacent to the park? (trends in use types) What are the predicted impacts of land use changes on park values? Are there detectable changes w/in park due to land use.	Aerial photography, mapping, plots	change detection maps
		Monitor water availability to park resources	H6	Water Quantity and Availability Within & Surrounding Parks	Is the quantity of water available to park resources changing? Are human withdrawals which influence water availability to park resources changing?	Stream gages, well monitoring, diversion records	Volume, rate, specific conductivity/salinity
	Park Use & Activities	Monitor debris-trash occurrence in terrestrial, coastal, riparian, wetland, and lacustrine habitats; in or near high use areas	H7	Litter/debris	What are levels of litter within parks? Where is littering/ dumping of trash taking place? (e.g. terrestrial, open ocean) What are areas of marine debris deposition?	surveys of activity & locations, identify spatial distribution, document/characterize source	quantity presence / absence, type & size
		Patterns of park visitation, use & damage due to marine recreational activities, groundings/anchor damage, including debris/damage from fishing, campers, & cultural practices	H8	Marine recreational activity impacts	Are use levels of marine recreational activities changing? What are the trends in observable damage to marine environments as a result of marine recreational use? Including damage from groundings/anchor damage, trampling, debris/damage from fishing, campers & cultural practices.	Mapping for anchor damage, timed visitor counts, periodic surveys of transects and/or quadrats (for damage assessments)	Visitor density (including dive hours), measure of damage (e.g. distribution & amount of severity of anchor damage, amount of lead sinkers, fishing line or net entangled on bottom, number of broken corals level/degree of trampling, water films)
		Monitor patterns of park visitation (e.g. timing, intensity), use & damage (terrestrial & marine)	H9	Footprint & Visitor Use Patterns	Are locations and/or intensity in use areas (visitor or management) changing? Are use levels associated w/detectable levels of resource change?	VERP program, repeated mapping of use areas, plot sampling	erosion, plant cover, quantify use levels
			H10	Subsistence Farming/Agriculture	What areas are affected by subsistence farming and how are these practices modifying plant communities?	Mapping/gps perimeter of farmed areas, aerial photos	area covered by disturbance, Distribution
		Monitor incidence & occurrence of commercial harvest activities	H11	Commercial Harvest	What are annual harvest levels of sand/coral? Is human harvest changing distribution, abundance, or other population characteristics of harvested resources? At what rate? (% of decrease) What are current trends (commercial activities) in bioprospecting, coral/sand mining?	Survey in various targeted habitats:pharmaceutical plants,thermal pools,coral reefs, intertidal zones,etc. Quantification of commercial activity, harvest levels, and of targeted population characteristics.Plot/transects and remote sensing	harvest composition, harvest quantity, rate or % of decrease, Commercial activity
		Monitor levels of take & species (marine, intertidal, freshwater, and terrestrial) or resources (coral, sand) related to cultural practices	H12	Cultural-based Harvest	What are trends harvest, including illegal species? Is human harvest changing distribution, abundance or other population characteristics? Can there be a balance between management goals or sustaining population numbers and culturally important species?	Transects, plots, systematic monitoring and/or population surveys of harvested species, creel surveys	collection statistics (quantity, age/size), species composition, counts by class, creel counts, Catch (take) per unit effort in control and harvested populations
	Management Zones	Monitor patterns and effects of use and management	H13	Management Zone uses	Are locations, extent and/or intensity in use areas (visitor or management) changing? Are use levels associated w/detectable levels of resource change?	mapping	quantify and qualify uses and extent(s)
		Monitor effects of management and use on wilderness character	H14	Wilderness Areas - HAVO, HALE, other Unofficial	Monitor to identify the need for, or effects of, management actions. Are wilderness areas being unacceptably changed?	Limits of acceptable change. Nature, magnitude, and source of impacts	Limits of Acceptable Change (LAC)

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Physical / Chemical Conditions	Climate & Air Quality	Monitor visibility	P1	Visibility	Is sight distance, light extinction, and quality reduced?	Aerosol filters, cameras, nephelometer	sight distance (extinction coefficient), particulate concentration, turbidity
		Track atmospheric concentrations of particulates and gases, emphasizing those with known human health or environmental impacts, determine deposition loads/influence on biogeochemical cycling	P2	Wet deposition	What are the concentrations of important nutrients and toxins? How much is deposited? How much do anthropogenic vs. volcanic vs. other natural sources contribute?	Precipitation samples	precipitation chemistry, concentrations/deposition estimates of major nutrients, toxins and trace species
			P3	Fog (Cloud water) deposition	What are the concentrations of important nutrients and toxins? How much is deposited? How much do anthropogenic vs. volcanic vs. other natural sources contribute?	fog water samples	fog chemistry, concentrations/deposition estimates of major nutrients, toxins and trace species
			P4	Atmospheric Gases: Climate Change Indicators, Human Pollutants, natural - volcanic	How are atmospheric gas concentrations changing? How does volcanic activity influence air quality? How do anthropogenic pollutants influence air quality? What is the influence on the biogeochemical cycle (how much is deposited)?	filters, real time analyzers, continuous or periodic monitoring depending on species information desired	concentrations of air toxics, CO2, O3 and other GHGs, trace species, deposition estimates
			P5	Atmospheric Particulates: climate change indicators, Human pollutants, natural - volcanic & marine	How are atmospheric particulate species and concentrations changing? How much is deposited? How much do anthropogenic vs. volcanic vs. other natural sources contribute? What is the influence on the biogeochemical cycle?	filters, real time analyzers, continuous or periodic monitoring depending on species information desired	dust, particle size analyses: pm10, pm 2.5, species, concentration of various species (including trace species), deposition estimates
		Monitor core weather/climate conditions within each park (on each island), provide baseline data for ecological research, fire danger forecasting, visitor information regarding weather related health and safety risks	P6	Solar radiation	How are solar radiation inputs, UV-B, photosynthetically active radiation (PAR), or other wavelengths, fluxes changing?	pyranometers, (PAR sensors, UVB radiometers, etc.), satellite data	upwelling & downwelling, direct & diffused; PAR, UVA, UVB
			P7	Weather & Climate	What are current conditions? What are ranges of climate parameters within each park? Are they changing?	weather stations (RAWS, COOP, NPS-ARD), fog monitors, fuel sticks, soil moisture/temp sensors, wetness sensors, satellite data, lidar data	wind, temperature, precipitation, relative humidity, fog immersion time, fuel moist/temp, soil moisture/temp, wetness,
		Document frequency, intensity and spatial extent of long term climate patterns and extreme events	P8	Extreme events, long-term patterns (weather & ocean)	How frequently do extreme events occur, and at what intensity? What are temporal trends? What is the spatial extent?	data from weather stations and wave/swell monitoring in parks, in addition to data mining, sources: NOAA, USGS, NWS	hurricanes/typhoons, storm waves, high water mark, ENSO, PDO, droughts, floods
		Identify spatial and temporal patterns of climate. Provide baseline data to help evaluate how stability and variability in climate affect natural populations, processes, and large scale ecological drivers.	P9	Climate Representations - 2- & 3- dimensional	How do weather/climate parameters change over varying ranges in space and time?	modeling or mapping	trade-wind inversion, wind, temperature, precipitation, cloud patterns, radiation budgets
	Soil, Water, & Nutrient Dynamics	Monitor physical ocean dynamics - relative sea level, tides and swells	P10	Ocean physical dynamics: relative sea level, tides, swells	What is the natural variability? What are temporal trends?	tide gauge, ADCP, GIS, buoy data, satellite data	maximum signal wave height, relative sea level, tide fluctuations
		Monitor cycles of nutrients and elements within soils and water--including carbonate (oceanic), nitrogen, and phosphorous	P11	Biogeochemical Cycles - Nutrient Cycling	How are processes changing over time (source, directions, levels of flow)?	monitoring plots	Aquatic senescence, Coral growth-CaCO3 deposition, Forest productivity (litter rain, incremental growth), Key constituents (N, K, CaCO3)
		Monitor soil erosion	P12	Soil Erosion	What are causes and locations of soil erosion, what are rates of change, what is land use and human impact?	erosion pins deployed together and integrated over watershed, sediment collectors, mapping, sediment fingerprinting	Areal distribution of rate of soil loss (mapping), transport out of watershed
		Monitor soil quality trends (physical, toxics/contaminants, other biologic and nutrients)	P13	Soil Quality - Biological	What are soil communities, and are they changing?	Soil sampling and analysis	bacteria, fungal/microrhizal, worms/nematodes/arthropods, bulk density
			P14	Soil Quality- Chemical	Are soil buffering and filtering qualities changing?	Soil sampling and analysis	appropriate WQ measures, cations, pH, soil composition, Total Nitrogen & Total Carbon
			P15	Soil Quality- Physical	Are physical soil properties changing?	Soil sampling and analysis	DOC, grain size, moisture content, parent material, percent organic matter, permeability, POC
		Monitor condition and extent of soil crusts	P16	Soil Crust Change (Arid-Semiarid habitats)	Where are soil crusts broken, what are pressures/impacts on soil crusts, and how are they distributed in space and time?	soil and geologic mapping, remote sensing, periodic change analysis	distribution of soil crusts, pH, rainfall, substrate composition, volcanic aerosol composition, wind spd/dir
		Monitor trends in surface water hydrology and flow regimes	P17	Flowing surface water hydrology	What are usual rates & range of flow? What is timing & magnitude of floods or droughts? Is erosion occurring, or are flow channels changing? What is the spatial distributionof the flow in question? What is the flow regimen, and what are the geomorphic conditions? What are base flow volume and seasonal trends? What are frequency and magnitude of floods or extremely low-flow events?	gauges, sampling at permanent sites, flow regionalization	discharge / recharge, diversion patterns, flood timing / magnitude, withdrawal & consumption rates, stream cross-section, stream discharge, stream gradient, rainfall, stream discharge over space/time
			P18	Stream channel habitat dynamics	Is erosion occurring? Are flow channels changing? Are substrate types changing?	mapping of streambed topology & substrate	bank depth, sinuosity, stream cross-section, stream gradient, substrate size
			P19	Water diversion levels	What proportion of water is being made unavailable for aquatic biota and designated uses?	gages, wells, sampling at permanent sites	relative quantity of water being diverted, seasonal, spatial & temporal diversion patterns
		Monitor wetland (incl. anchialine ponds) water flow exchange dynamics, size, and distribution, measure movement of water between streams and groundwater. Includes wetlands, lakes, ponds (fresh & anchialine), springs and seeps.	P20	Wetland hydrology	What are freshwater/saltwater recharge rates? What is habitat extent and distribution? What are temporal trends in recharge rates and habitat extent? What are groundwater levels, residence times, infiltration, permeability, and evaporation in wetlands? What is the relationship between groundwater and wetlands in anchialine pools?	measure salinity, residence time, mapping, samples from wells	flood timing/magnitude, flow, parent material/geomorphology, plant cover/ species present, pool size, depth & salinity, rainfall, sediment loads, pH, tidal fluctuation, stream cross-section, stream discharge, stream gradient, bank erosion, sedimentation patterns
		Monitor ground water flow rates and direction of movement (recharge)	P21	Groundwater dynamics	What are rates of subsurface flow? What is level of freshwater/saltwater mixing? What are flow patterns?	well, seep, & spring discharge measurements	discharge/recharge, injections (sewage), permeability, tide fluctuations, withdrawal & consumption rates, salinity, seepage

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Physical / Chemical Conditions	Water Quality	Monitor water quality network core parameters	P22	Ground Water Quality Network Core parameters	What are the range and variance of the network core water quality parameters? What are the temporal and spatial trends?	water sampling from dedicated monitoring wells in addition to supply wells	temperature, pH, salinity (sp. cond.), dissolved oxygen, total nitrogen, total phosphorous, depth		
			P23	Marine Water Quality Network Core parameters	What are the range and variance of the network core water quality parameters? What are the temporal and spatial trends?	in-situ measurements and collection of samples at established sites including controls	temperature, pH, salinity (sp. cond.), dissolved oxygen, PAR, total nitrogen, total phosphorous, chlorophyll a, depth		
			P24	Surface Water Quality Network Core parameters	What are the range and variance of the network core water quality parameters? What are the temporal and spatial trends?	in-situ measurements and collection of samples at established sites including controls	temperature, pH, salinity (sp. cond.), dissolved oxygen, PAR, total nitrogen, total phosphorous, chlorophyll a, depth		
		Monitor supplemental water quality parameters	P25	Ground Water Quality Supplemental parameters	What are the range and variance of the supplemental water quality parameters? What are the temporal and spatial trends?	water sampling from dedicated monitoring wells in addition to supply wells	inorganic nutrients (NO2/NO3, PO4, NH4, SiO4), alkalinity, anions, cations, redox, total organic carbon.		
			P26	Marine Water Quality Supplemental parameters	What are the range and variance of the supplemental water quality parameters? What are the temporal and spatial trends?	in-situ measurements and collection of samples at established sites including controls	inorganic nutrients (NO2/NO3, PO4, NH4), total suspended solids/turbidity/secchi disk, alkalinity, anions, cations, redox, total organic carbon, chlorophyll b, chlorophyll c		
			P27	Surface Water Quality Supplemental parameters	What are the range and variance of the supplemental water quality parameters? What are the temporal and spatial trends?	in-situ measurements and collection of samples at established sites including controls	inorganic nutrients (NO2/NO3, PO4, NH4), total suspended solids/turbidity/secchi disk, alkalinity, anions, cations, redox, total organic carbon, chlorophyll b, chlorophyll c		
		Monitor microbiological water quality parameters	P28	Ground Water Quality - Microbiology	What are the range and variance of microbial water quality parameters? What are the temporal and spatial trends?	water sampling from dedicated monitoring wells in addition to supply wells	bacteria, viruses, protozoans, biological oxygen demand		
			P29	Marine Water Quality - Microbiology	What are the range and variance of microbial water quality parameters? What are the temporal and spatial trends?	collection of samples at established sites including controls	bacteria, viruses, protozoans, biological oxygen demand		
			P30	Surface Water Quality - Microbiology	What are the range and variance of microbial water quality parameters? What are the temporal and spatial trends?	collection of samples at established sites including controls	bacteria, viruses, protozoans, biological oxygen demand		
		Monitor toxic and contaminant levels in water	P31	Ground Water Quality - Toxics & contaminants	What are the range and variance of toxics and contaminants in groundwater? What are the temporal and spatial trends?	water sampling from dedicated monitoring wells in addition to supply wells use of fat bags (SPMDs)	chemical oxygen demand, heavy metals, herbicides, organics, pesticides		
			P32	Marine Water Quality - Toxics & contaminants	What are the range and variance of toxics and contaminants in marine water? What are the temporal and spatial trends?	water sampling, sediment sampling, animal tissue sampling	chemical oxygen demand, heavy metals, herbicides, organics, pesticides, bioassays		
			P33	Surface Water Quality - Toxics & contaminants	What are the range and variance of toxics and contaminants in surface water? What are the temporal and spatial trends?	water sampling, sediment sampling, animal tissue sampling	chemical oxygen demand, heavy metals, herbicides, organics, pesticides, bioassays		
		Monitor biotic (communities) indicators of water quality	P34	Biotic Indicators of Marine Water Quality	Are benthic invertebrate & algal communities indicative of impaired water quality?	Periodic benthic quadrat sampling (sediment & sessile organisms).	species richness, composition, biomass, presence/absence of indicator species		
			P35	Biotic Indicators of Surface Water Quality	Are benthic invertebrate & algal communities indicative of impaired water quality?	Periodic benthic quadrat sampling.	species richness, composition, biomass, presence/absence of indicator species		
		Geology	Hazards	Monitor surface volcanic activity (lava flows, eruption events & ground deformation)	P36	Volcanic Unrest - Ground Deformation	What role does volcanic activity and deformation play in maintaining public safety, park facilities, and how do they affect natural processes?	Dry and wet tilt meters, dilatometers, GPS	GPS, subsurface temp, tilt meters
					P37	Volcanic Unrest - Lava Flows	What role do lava flows play in maintaining public safety, park facilities, and how do they affect natural processes?	Remote sensing, visual observation, tilt meters and dilatometers, GPS ground deformation	tube mapping, flow direction/magnitude, GPS
				Monitor volcanic & non-volcanic seismicity	P38	Seismicity of Non-Volcanic Origin	Can we identify trends and predict hazards?	Seismometers (local and global)	tilt meters, seismometers, dilatometers (pressure gauges), EDM (Electronic Distance Measuring)
					P39	Seismicity of Volcanic Origin	Can we identify trends and predict hazards?	Seismometers (local and global)	tilt meters, seismometers, dilatometers (pressure gauges), EDM (Electronic Distance Measuring)
	Monitor extent, location, and causes of mass wasting events (e.g. landslides, debris flows, flash floods, tsunami)			P40	Mass Geologic Wasting	Can we predict slope failure hazards to protect habitats and human safety? Can we monitor or identify causes? What are temporal trends?	Rainfall and other climactic analyses (precursors and catalysts), stream gauges, remote sensing	soil saturation, soil/ground creep, substrate composition/permeability, substrate distribution	
	Measure the impacts from extreme events such as coastal stream flooding, storm/hurricane overwash, and tsunami inundation			P41	Marine Inundation	What area the frequency and magnitude and distribution of marine inundation events, what park resources are subject to inundation during stream flooding, tsunamis, and large storms or big wave events?	Tide gauges, seismic networks, rain gauges, stream gauges, oceanic buoys, field mapping of water and debris lines (both horizontal incursion and vertical elevation)after an event, photograph damage and changes to park resources	water (sea) levels, erosion/deposition, extent, discharge	
	Landforms		Monitor shoreline dynamics and change in shoreline position	P42	Coastal Shoreline Change (erosion & accretion)	Where are shorelines advancing, retreating, or stable, and what is the rate of change?	historical shoreline analysis (air photos, T-sheets), beach profiles, tide gauge data to examine local sea-level trends, field observations and measurements	human development/infrastructure, substrate composition, shoreline aspect/position/slope, sea level, nearshore physical oceanography, historical shoreline analysis, amount of change (m) over the time span between measurements (years).	
			Track dune locations and topography	P43	Dune Change (erosion & accretion)	Are drought & desertification influencing topsoil transport and seed/nutrient transport patterns?	remote sensing, field investigation, periodic change analysis	grain size & parent material, rainfall, soil crust development, substrate composition, substrate distribution, veg stabilization, wind regime	
			Identify and monitor the extent of permafrost	P44	Permafrost on Big Island summits	Is extent of permafrost declining? Influence on ground subsidence, slope failure, etc?	Remote Sensing (ground penetrating radar), satellite thermal analysis, drilling	temperature, volcanic activity (heating), permafrost thickness, rainfall	
			Monitor karst and non-karst cave and lava tube habitat characteristics, topography, and extent	P45	Cave Geology: non-karst and karst	What are patterns of mineral accretion? Where & when are collapse/skylight formation or enlargement occurring? Are changes in karst systems leading to potential bedrock collapse, well yield disparities, poor groundwater quality, soil instability?	geologic mapping, periodic measurement of physical parameters and feature types, remote sensing, surface water chemistry, groundwater discharge patterns	dimensions, feature size, extent, baseline mapping, groundwater flow/quality	
	P46	Cave Environmental conditions		How does human activity & cultural practices impact and change cave systems above ground (outside) and inside? How do natural/human induced impacts affect environmental cave conditions (temp, humidity, light, etc.)?	Station/plot data, photo points (repeat photography)	litterfall, Species distribution & abundance, human use levels, temperature, humidity, ground compaction, etc.			

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Biotic Integrity				Track the number of Threatened, Endangered, and Species-of-Concern species (plant, terrestrial vert, and marine) in each park as a measure of T, E, SoC species richness. Provide park managers with a quick, easy point of reference for management decisions, and/or to point to more focused monitoring or research needs.	B1	T, E, S-o-C Species Richness	Are the numbers of Threatened, Endangered, and Species-of-Concern species represented in each park increasing, decreasing, or steady?	Presence/absence surveys, with periodic inventory for new T, E, S-o-C species. Consider including "rare" species as well.	presence/absence.	
	Terrestrial Ecosystems	Vegetation	Landscape	Monitor patterns of distribution & extent of community types	T1	Soil and Pollen Landscape History	Do the parks contain intact paleolandscapes? Are these resources being altered or disturbed? Are species represented in the pollen record that are now absent from the park? What is the relative sensitivity of natural landscapes to disturbance? What are recent (historical) changes in vegetation community types? What is the timing of arrival of alien invasives?	Mapping; Pollen and charcoal assemblages, macrofossils, soil horizons, etc.	Species composition,Rate of change?	
					T2	Ecozone Boundaries	Are locations of ecotones changing due to long term natural/unnatural perturbations? Are the communities that comprise ecological boundary zones changing(increasing/decreasing in size)?	vegetation mapping, landscape photography, high spatial resolution plots	change detection maps	
					T3	Landscape Fragments and Land Cover	How are the distributions of plant communities and land cover inside and immediately outside the Parks changing over time? Are fragments or patches of natural vegetation decreasing in size or persisting over time?	Mapping, repeat imaging, transects, plots, histories, Where possible use traditional land divisions such as Ahupua'a for monitoring units	Spatial statistics, Vegetation type	
				Monitor fire regimes and effect on vegetation at the landscape level	T4	Fire Effects & Dynamics: Landscape Level	What is current or recent fire regime? What is extent & intensity of fires? What are current natural and anthropogenic ignition sources ? What are the impacts of fire on landscape pattern and patch viability?	Transects, plots, histories, mapping. Erosion pins and sediment collectors for erosion monitoring.	Change in vegetation structure, erosion, or nutrient loss following fire, landscape history.	
				Track Patterns of Forest Health and Dieback	T5	Forest Dieback	What percentage of the native components of natural vegetation in a population are declining or dying due to natural trends (including native diseases) or non-native influences? What proportion are dying due to natural vs. non-native influences? What are temporal trends?	Transects, plots, population surveys, mapping of affected areas.	Plant cover, density, vigor, size classes, species composition, density of stressor relative to degree of dieback, History of Disturbance, landscape history, Stand history, Extent and distribution of dieback	
				Monitor effect of catastrophic events (other than fire) on vegetation	T6	Other (than fire) Disturbance events	What are the impacts of hurricane, typhoon, drought etc. on vegetation communities and distributions of interest? What are the implications to plant community composition and structure? What are impacts on Threatened , Endangered and SOC. species?	Transects, plots, population surveys of focal plant vertebrate and invertebrate species. Erosion pins, sediment collectors, and mapping for erosion monitoring.	Change in vegetation structure, cover, density, erosion, nutrient loss, species composition	
			Community	Monitor fire regimes and effect on vegetation at the community level	T7	Fire Effects & Dynamics: Community Level	What is current or recent fire regime? What are the implications to plant community composition and structure resulting from fire? What are impacts to threatened, endangered and SOC species of plants? What are impacts of fire to vertebrate and invertebrate groups?	Transects, plots, population surveys of focal plant, vertebrate and invertebrate species.	Change in vegetation structure, cover, density, vigor, size classes, recruitment rates, growth rates, species composition, presence/absence and abundance of focal groups	
				Monitor community dynamics, structure, function, and composition	T8	Rare and Focal Plant Community Biodiversity	Are there detectable changes in selected communities of interest? What is the relative abundance of native and non native species of vascular or non-vascular plants in communities of interest? What plant species and natural communities are rare in the parks?	Transects, permanent plots.	Presence/ absence, abundance of focal species and groups; diversity indices both within and across plant communities; Changes in structure, density, cover, and trends in selected focal groups of plant species.	
					T9	Plant Succession	What are trends in plant community composition and structure of representative vegetation types (including epiphytic plants and both vascular and non-vascular plants), regardless of management treatment or land use?	Transects, permanent plots, mapping, remote sensing, long-term monitoring of tagged species	Cover, density, vigor, size classes, growth rates, species composition, long -term changes in structure, spatial relation of individuals	
				Monitor effects of management on native communities	T10	Recovery/Change of Native Vegetation Following Management	What are trends in plant community composition and structure following management (including : Alien plant control, Small mammal control, Feral ungulate control or removal, Invasive alien invertebrate control, and Outplanting/seeding activities)? What are impacts of management on biodiversity and on common species or community types? What are the effects of alien species control on other alien species?	Transects, plots. Population surveys of native and alien invertebrates.	Cover, density, vigor, size classes, species composition, recruitment rates. Focal plant flower and seed production. Abundance and distribution of alien invertebrates and native pollinators.	
			Population	Monitor effects of biocontrol on native and invasive species	T11	Biocontrol of Plants	What is the long-term impact/efficacy of plant biocontrol (using either plant pathogens or invertebrates) on populations of the control target? Are non-target plants, especially natives, being affected?	Plots & transects for plants, long term monitoring of biocontrol effects on populations	Infestation rates, cover, density, vigor, size classes, recruitment rates, damage indices for both natives and target alien species. Presence and abundance of biocontrol agent.	
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species.	T12	Native Plant Species Protection	What are the distribution, abundance, and demographics of threatened, endangered, rare and focal native vascular and non-vascular plant species? Is the overall number of rare plant species increasing or decreasing? Are plant populations reproducing at sustaining levels? Is pollination, seed bank, seed set, and seedling recruitment adequate to maintain levels? Is genetic diversity being maintained?	Mapping, plots, counts in size classes. Soil cores and subplots for seed banks. Flower and fruit monitoring at focal plant populations. Genetic analysis of focal species samples.	Phenology, survival, soil seed bank, population structure, distribution, density, reproduction. Genetic similarity of individuals in populations.	
				Monitor disease incidence and impacts, especially on native species	T13	Species / Community health	What are the incidences and levels of plant pathogen and disease (including native, established alien, and incipient alien disease) in populations? Are diseases/pathogens affecting populations within the park? What are trends in disease/pathogen including rate and direction of spread? What are the causes of disease and mortality in selected plant populations?	Transects, plots, population surveys, Surveys in high risk sites; rapid assessment of extent of infestations passive surveillance; education, outreach, public reporting, and follow-up.	Presence-absence, identification & distribution of targeted "blacklist" species & other novel (previously undetected) invasives along with host and/or vector species involved	
				Monitor extent and response to treatment of established invasive species	T14	Established Alien Species - Plants	What is the distribution and abundance of established alien plants (including mosses)? What is the rate of spread of alien plants? What is the relative abundance of native and invasive species? What are the impacts on native species of vascular and nonvascular plants? What is the potential of alien plant species to invade and dominate communities?	Mapping, transects, plots, counts in size classes. Soil cores and subplots for seed banks.	Distribution mapping, frequency, cover, density and population structure of alien and native species. Species composition of seedbanks.	
				Monitor occurrence of non-established (incipient) invasive species	T15	Alien Incipient Invasive Vascular and Non-vascular Plants and Fungi	What potential high-impact species have breached the border-protection system and have potential to reach the park? What is the nature and extent of infestation? Is eradication/containment feasible and where should efforts be focused? Is alien species present in park, and if so, what is the nature and extent of infestation? What is the mode of dispersal through which the species entered the park? What are potential impacts on native species or communities? What are the most likely invaders of parks?	Shared surveillance by multiple agencies and public, including follow-up on reports; surveys in high- risk sites inside and outside parks (eg.roadsides, trails, ports, disturbed sites). Observations of seed dispersers and collection of seed rain information. Soil cores and subplots for seed banks. Monitoring of pathwasys and ports of enty: surveys in high-risk sites (e.g. roadsides, trails, ports, disturbed sites), monitoring of specific buffer zones around areas of special concern within the park; rapid assessment of extent of infestation	Presence/ absence, assessment of extent of infestation. Density and size class of impacted native plant populations. Species composition of affected native communities. Species composition of seedbanks. Identification and distribution of targeted "blacklist" species and other (previously undetected) invasives.	

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Biotic Integrity	Terrestrial Ecosystems	Consumers	Community	Detect changes in the dynamics, structure, composition and/or function of selected communities within defined geographic areas. Periodically inventory to document new species in parks. Where appropriate, parks may emphasize off-shore (or other forms of) islet refugia	T16	Terrestrial Invertebrate Biodiversity	What are trends in distribution, abundance, and diversity of speciose groups within parks and across landscapes? Are species being locally extirpated or going extinct?	Population surveys, transects, plots, mapping	Abundance, density, demographics, distribution, diversity, evenness, richness
					T17	Terrestrial Vertebrate Biodiversity (including off-shore islet refugia)	Are selected native vertebrate communities or guilds changing? This includes changes in abundance of selected species (determined from population surveys), and/or changes in the identity and number of species present in the community or guild of interest (determined from presence/absence monitoring).	Population surveys, presence/absence surveys. Periodic inventories focused on picking up new species records (especially T, E, S-o-C species, and seabird colonies) and/or locations.	Within defined areas or specified communities: abundance and trends of selected vertebrate species or groups, species richness
				Monitor effects of management on fauna communities	T18	Recovery/change of native fauna with habitat restoration	What is the response of native vertebrate and invertebrate populations to habtiat restoration, including alien control and outplanting and seed-sowing activities? Which native species are recolonizing restored areas? Which ones are not?	Population surveys, transects, plots (monitoring of areas where seeds have been broadcast and native species outplanted), mapping	Abundance, density, size classes, vigor, species composition, seedling recruitment, growth rates, Cover, animal reproductive success, animal population size, animal population growth rates, survivorship, distribution, diversity, evenness, richness
			Population	Monitor effects of biocontrol on native and invasive species	T19	Invertebrate Biocontrol of Invertebrates	What is the impact of biocontrol agents on native and non-native invertebrates (including moths, beetles, snails, and parasitoids)? What is the impact on target species?	Population surveys, transects, plots, mapping, rearing	Parasitism/predation rates; abundance/density, demographics, distribution of hosts and control agents
				Monitor population health by detecting changes in population size and distribution of native and non-native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species	T20	Selected native and alien forest Bird and Bat populations (can include T & E spp.)	Are the demographics of selected native, endemic, or focal forest bird and bat species changing? If so, are changes deleterious, and can we control or reduce threats to these populations?	Population surveys, including demographic measures (size/age structure, reproduction, recruitment, etc.) and prevalence of disease, pathogens, and/or population threats. (Forest bird methods differ from those for raptors or bats; and fruit bat methods will differ from insectivorous bats.)	Population demographics, density, distribution. Prevalence of disease, pathogens, other population threats.
					T21	Herps (native)	Are distribution, abundance, other population characteristics, or habitat changing? Determine population levels over time.	Population surveys. A variety of standardized techniques (depending on target species) -- pitfall traps, baited traps, etc.	Abundance / density, distribution
				Monitor population health of native, non-native, endemic, or focal species through measurement of demographics (size/age structure, reproduction, recruitment, etc.) for selected species; and identification of disease, pathogen, or other threats.	T22	Seabird, Shorebird, Waterbird Population Health (can include T & E spp.)	Are the demographics of selected seabird, shorebird, and waterbird species changing? If so, are changes deleterious, and can we control or reduce threats to these populations?	Population surveys, including demographic measures (size/age structure, reproduction, recruitment, etc.) and prevalence of disease, pathogens, and/or population threats. (Methods will differ for seabirds, shorebirds, and waterbirds.)	Population demographics, density, distribution. Prevalence of disease, pathogens, other population threats. (For seabirds, probably focusing on nesting or roosting habitat vs at-sea habitat except possibly for near-shore feeders.)
				Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts - and the habitat where present. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.)	T23	Terrestrial Invertebrate Indicators Associated with Habitat Quality	What are trends in distribution and abundance of invertebrate indicator species?	Population surveys, transects, plots, mapping	Abundance, density, demographics, distribution
				Monitor population health of native, endemic, or focal species through measurement of demographics (size/age structure, reproduction, recruitment, etc.) for selected species; and identification of threats.	T24	Terrestrial Invertebrate Focal Species and Species of Special Concern (T, E, S-o-C, rare, and charismatic species)	What are trends in distribution, abundance, other population characteristics, and habitat? Are threats changing? If so are changes deleterious, and can we control or reduce threats to these populations?	Population surveys (including demographics), transects, plots, mapping	Abundance, density, demographics (size/age, structure, reproduction, recruitment, etc), distribution, documentation of other population threats
				Assess health of terrestrial vertebrate populations, particularly sensitive, native species. Detect, identify, and quantify causes of mortality and morbidity and their impacts on the populations. Provide early detection information to help prevent occurrence and/or spread of potential new threats to populations.	T25	Wildlife (terrestrial vertebrate) health and targeted monitoring for disease/pathogens, esp among native species (can include T & E)	What are the prevalences and levels (how severe), and trends in known causes of morbidity and mortality in targeted popns? Where cause-effect is clearly established, are these affecting the populations? For targeted potential (incipient) causes of mortality and morbidity: are these present in popn or geographic area of concern? Are they present in other popns or in locations outside the immediate area of concern? If so, what are rates and directions of spread?	Known causes: specimen and/or carcass collection (may include telemetry to recovery carcasses), host or vector surveys/sampling; surveys of affected populations to determine popn status and impacts. Potential causes: Surveys in high risk sites; passive surveillance (opportunistic carcass or sick animal collection); education & outreach to encourage public reporting; survey or report follow-up where needed; rapid assessment of extent of any infestations	Disease or threat prevalence, level, or presence/ absence; distribution and numbers of host and/or vector species involved; abundance or density of affected population. Potential causes: presence/absence; distribution, ID, and numbers of host and/or vector spp.
				Monitor extent and effects of alien feral ungulates, and monitor their response to management treatment.	T26	Status of Established Alien Feral Ungulates, and Response to Treatment	What are the relative abundance, distribution, and population trends of feral ungulates? Are native plant and animal species' abundance or distribution changing in response to feral ungulates, or in response to efforts to control feral ungulates?	Treatment and control transects, plots, or sites using appropriate methods to assess both invasive and native organisms of interest (VCP, transects, etc.); surveys for predators using appropriate methods to estimate population size and distributionTreatment and control Transects/plots (for plants); other methods appropriate for native vertebrates of interest (VCP, transects, etc.); population surveys for predators	Plants: species composition, population and/or community structure. Animals: abundance or density, possibly presence/absence, and/or other measures of critical life stages identified as impacted by predators. Predators: population indices, presence/ absence, mapping.Plants: species composition, population and/or community structure. Animals: VCP, transects, other methods to monitor critical life stages identified as impacted by predators. Predator population indices, presence/ absence
				Monitor extent and response to treatment of established invasive species	T27	Established Alien Species - Invasive Terrestrial Invertebrate Pests of Natural Systems	What are the abundance, distribution, and seasonal and year-to-year variations in populations? What are trends in impact? How effective is control?	Population surveys, transects, plots, mapping	Abundance, density, demographics, distribution of aliens and native indicator species

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			Monitor extent and effects of predatory and omnivorous alien terrestrial verts, and monitor their response to management treatment.	T28	Status of Established Alien Predatory and Omnivorous Terrestrial Vert Species, and Response to Treatment	Are native plant and animal species' abundance or distribution changing in response to predatory or omnivorous invasives, or in response to efforts to control these invasives? What are trends in predatory and omnivorous invasive species populations?	Treatment and control transects, plots, or sites using appropriate methods to assess both invasive and native organisms of interest (VCP, transects, etc.); surveys for predators using appropriate methods to estimate population size and distribution.	Plants: species composition, population and/or community structure. Animals: abundance or density, possibly presence/absence, and/or other measures of critical life stages identified as impacted by predators. Predators: population indices, presence/ absence, mapping.
			Monitor extent and response to treatment of established invasive species	T29	Established Alien Species - Terrestrial Invertebrate Pests of Agricultural Systems (including traditional cultivation)	What are the abundance, distribution, and seasonal and year-to-year variations in populations? What are trends in impact? How effective is control?	Population surveys, transects, plots, mapping	Infestation rates of native and alien hosts
				T30	Established Alien Species - Terrestrial Invertebrate Pests (human structures)	What is the impact of invertebrate pests on historic and other culturally significant structures?	Periodic sampling of structures	Infestation rates, structural damage
			Monitor for invasive terrestrial vertebrate species known to pose potential ecological threats (incipient species). Where appropriate, monitor response of these invasive species to management treatment.	T31	Targeted monitoring for (incipient) invasive terrestrail vertebrate species known to pose potential threats	What potential high-impact species have breached the border-protection system and have potential to reach the park? What is the nature and extent of infestation? Is eradication/containment feasible and where should efforts be focused? What are potential impacts? Is species present in park? If so, what is the nature and extent of infestation? Are native plant and animal species' abundance or distribution changing in response to the invasive or its control? What are the pathways and points of entry?	Detection: surveys in high- risk sites; follow up on reports; education and outreach to encourage public reporting. Impacts and reponse to treatment: treatment and control transects, plots, or sites using appropriate methods to assess both invasive and native organisms of interest (VCP, transects, etc.); surveys for non-established predators using appropriate methods to estimate population size and distribution.	Identification & distribution of targeted 'blacklist' and other novel (previously undetected) invasives. Presence/ absence; predator population indices and mapping; rapid assessment of infestation extent. Native plants: species composition, population and/or community structure; native animals: abundance or density, possibly presence/absence, and/or other measures of critical life stages identified as impacted by predators.
			Monitor occurrence of non-established (incipient) invasive species	T32	Alien Incipient Invasives - Terrestrial Invertebrates	What potential high-impact species have breached the border-protection system and have potential to reach the park? What is the nature and extent of infestation? Is eradication/containment feasible and where should efforts be focused? Which species are present in park? What is the nature and extent of infestation? Where should efforts be focused? What are potential impacts?	Active monitoring (transects, plots,light trapping, etc.) in high-risk sites;rapid assessment of extent of infestation; mapping of new discoveries; education, outreach, and public reporting, follow-up on reports	Identification & distribution of targeted 'blacklist' and other novel (previously undetecteed) invasives. Presence/absence, distribution, rapid assessment of extent of infestation
		Cave Systems	Community	T33	Cave & lava tube communities	What are trends in distribution, abundance, other population characteristics, and habitat quality? Are threats changing?	Population surveys, mapping; root type and abundance	Abundance, density, demographics, distribution, diversity, evenness, richness of natives and aliens
Biotic Integrity	Freshwater Ecosystems	Producers	Community	F1	Aquatic primary producer community composition, structure & biomass	What species are present? What are rates of production? What is the proportion of native vs. alien species contributing to productivity? Are there long-term changes in communities of aquatic primary producers? Where are algal blooms present? Includes benthic & planktonic species.	Periodic benthic quadrat sampling and/or plankton tows (depending on habitat).	trends in cover, density, diversity over time, distribution, species composition & biomass
				F2	Wetland & riparian plant community composition, structure & biomass	What species are present? What are rates of production? What is the proportion of native vs. alien species contributing to productivity? What are rates of riparian input (leaf litter, etc.) into aquatic habitat? Are there long-term changes in wetland & riparian plant communities?	Periodic transects & plot surveys, mapping, litter traps, surface water sampliig	trends in cover, density, size classes, litterfall, diversity over time, distribution, demographics, species composition, litter volume per species
			Population	F3	Established aquatic/wetland invasive plant & algal species distribution & abundance	What is the present extent of occurrence? Are there changes in extent over time?	Periodic transects & plot surveys, mapping.	presence/absence, trends in abundance, distribution and density
				F4	Incipient aquatic/wetland invasive plant & algal species distribution & abundance	Is species present nearby? If so, what is the present extent and nature of occurrence? What are potential pathways for dispersal?	Periodic sampling of freshwater habitats outside of parks (transects & surveys, mapping), including identified pathways of dispersal.	presence/absence, trends in abundance, distribution and density
		Consumers	Comm unity	F5	Aquatic & Riparian animal community structure & composition	What species are present? Are there long-term changes in native fish and aquatic invertebrate communities (composition, species richness, presence of aliens, etc.)?	Population surveys, periodic quadrat netting/trapping, visual transect censuses, plots, mapping.	Trends in community diversity, density over time, abundance, demographics, distribution, evenness, richness
			Population	F6	Disease & parasites of aquatic animals	What is the incidence and level of disease in populations of aquatic animals?	Visual surveys of possibly affected populations, opportunistic collections of dead animals, tissue samples from non-native vector species	disease/parasite occurrence & frequency
				F7	Native aquatic animal focal species distribution & abundance	Is species present? If so, what are trends in population numbers, reproduction, distribution and density? Includes shrimp, fish, molluscs and insects.	Periodic quadrat netting/trapping, larval drift netting, visual transect censuses, mapping.	presence/absence, trends in abundance of different size/age classes, distribution and density
				F8	Established aquatic invasive animal species distribution & abundance	What is the present extent of occurrence? Are there changes in extent over time?	Periodic quadrat netting/trapping, visual transect censuses, mapping.	presence/absence, trends in abundance, distribution and density
				F9	Incipient aquatic invasive animal species distribution & abundance	Is species present nearby? If so, what is the present extent and nature of occurrence? What are potential pathways for dispersal?	Periodic sampling of freshwater habitats outside of parks (quadrat netting/trapping, visual transect censuses, mapping), including identified pathways of dispersal.	presence/absence, trends in abundance, distribution and density

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Biotic Integrity	Marine Ecosystems	Landscape	Monitor patterns, distributions & extent of landscape-level benthic habitat types	M1	Benthic habitat	Are the distributions of large scale habitat types (inside and immediately outside the parks) changing over time (i.e. lagoons, algal/coral reef cover)? Is reef erosion/accretion occurring?	Habitat mapping	Distribution, relative abundance, cover by type, rugosity
			Monitor patterns, distributions & extent of landscape-level intertidal habitat types	M2	Intertidal habitat	What are the trends in the large scale ecological/geomorphological & habitat type changes?	Mapping	Distribution
		Community Structure & Dynamics	Monitor diversity (composition & abundance) and distribution of benthic marine Invertebrates and algae (including coral reef, colonized basalt, sand bottom, etc.)	M3	Coral and other marine invertebrate community	Are there long-term changes in benthic community diversity (abundance and composition) and distribution of selected native communities? What are the community dynamics?	Transects, quadrats (including photo, video)	Species composition & counts, percent cover of species, diversity, density/abundance, rugosity, coral growth rates
			Monitor intertidal biodiversity, including community dynamics, structure & composition of intertidal vertebrates, invertebrates, algae and vascular plants	M4	Intertidal community	Are there long-term changes in selected native communities' composition, distribution, cover?	Population surveys, transects, quadrats, mapping	Abundance and trends of selected assemblages or groups, evenness, richness, distribution, assemblages of foundation species
			Monitor community dynamics, structure and composition of water column marine vertebrates and invertebrate biodiversity (encompasses fish, squid & marine mammals)	M5	Marine fish assemblage	What are the trends in community composition & distribution in selected native communities?	Transects, distance sampling, timed swim counts	Relative abundance, demographics, diversity
			Monitor community dynamics, structure, and composition of marine algae and vascular plant communities, including mangroves and seagrass	M6	Marine algae and vascular plant community	Are there long-term changes in selected native communities' composition, distribution, cover?	Transects, quadrats (photo, video), mapping	Distribution, species composition & diversity, density, biomass, shoot density (seagrass)
		Population Dynamics	Monitor population size, distribution of native endemic or focal species. Where appropriate measure demographics (size/age structure, reproduction, recruitment, etc) of selected indicator species	M7	Focal marine fish population	What are the trends in abundance and distribution of selected marine fish populations? And if applicable/selected, what are the size/age classes?	Transects, mapping, population characteristics (demographics) of target species	Abundance, distribution, demography (size/age class frequency), qualitative data including general health and color morph
			Monitor population size, distribution of native endemic or focal species. Where appropriate measure demographics (size/age structure, reproduction, recruitment, etc) of selected indicator species	M8	Focal marine algae and vascular plant population	What are the trends in cover and frequency/density of selected marine algae and vascular plant species (including mangroves and seagrass)?	Transects, quadrats, species sampling for select turf species, crustose corallines and frondose algal species	Frequency for solitary algae, cover by species, demographics, recruitment, reproduction, growth rates. Qualitative data including general health.
			Monitor population size, distribution of native endemic or focal species. Where appropriate measure demographics (size/age structure, reproduction, recruitment, etc) of selected indicator species	M9	Focal marine coral and other invertebrate population	What are trends in abundance, distribution of selected coral and/or invertebrate species? If applicable/selected what are the trends in reproductive indexes, growth, survival and recruitment of selected species?	Population surveys, transects, quadrats (photo and/or video), mapping	frequency/density (number per unit area), distribution, growth rates, survival, recruitment rate, reproductive index. Qualitative data, including general health
			Monitor population size, distribution of native endemic or focal species. Where appropriate measure demographics (size/age structure, reproduction, recruitment, etc) of selected indicator species	M10	Focal marine Threatened & Endangered Species	What are trends in distribution & abundance of protected marine species or selected species of concern? What are the trends in recruitment, growth & survival rates for those species selected? Are changes and trends deleterious, and can we control or reduce threats to these populations?	Population surveys, transects, quadrats, mapping, marine mammal surveys, periodic telemetry	Abundance, demography (where appropriate), distribution, recruitment, growth, survival. Prevalence of disease, pathogens, other population threats. Qualitative data including general health
			Monitor extent and occurrence of established and incipient alien/invasive marine species	M11	Marine alien/invasive extent and occurrence	What are the trends in the incidence and level of infestation of alien/invasive species?	Population surveys, transects, quadrats, mapping	Presence/absence, trends in abundance, distribution and density, demography?, lab taxonomy?
			Assess health of populations of marine biota, particularly sensitive, native species. Detect, identify, and quantify causes of mortality and morbidity, parasites and pathogen incidence, and their impacts on the populations. Provide early detection information to help prevent occurrence and/or spread of potential new threats to populations.	M12	Marine biota health	What are the prevalences and levels (how severe), and trends in known causes of morbidity and mortality in targeted population? Where cause-effect is clearly established, are these affecting the populations? For targeted potential (incipient) causes of mortality and morbidity: are these present in population or geographic area of concern? Are they present in other populations or in locations outside the immediate area of concern? If so, what are rates and directions of spread?	Known causes: specimen and/or carcass collection (may include telemetry to recovery carcasses), host or vector surveys/sampling; surveys of affected populations to determine popn status and impacts. Potential causes: Surveys in high risk sites; education & outreach to encourage public reporting; survey or report follow-up where needed; rapid assessment of extent of any infestations	Disease or threat prevalence, level, or presence/absence; distribution and numbers of host and/or vector species involved; abundance or density of affected population. Stage of disease/infestation, host condition. Potential causes: presence/absence; distribution, ID, and numbers of host and/or vector spp.

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